

# TEACHING STATEMENT: HANDS-ON DESIGN ENGINEERING

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### PEDAGOGY.

President Thomas Magnanti, founding President of the Singapore University of Technology and Design and MIT full Professor, recently awarded Singapore's Gold Medal for Public Administration gave an address at the opening ceremony of SUTD's first graduation event. He spoke about the differentiating factor of a university in our digital era where the world's most advanced coursework materials are available for free online. What is the role of the university when information is free? It is not the access to raw information but rather the interactive experiences that emerge between students as they engage hands-on projects. Hands-on learning, in concert with deep theoretical foundations, leads to lasting learning outcomes. I have co-authored several award-winning papers on the topic of designettes, which break down the necessary characteristics of hands-on learning projects. This approach, and my own pedagogical style, relies heavily on the Kolb's Cycle of learning. The concept is to cycle between demonstration, theoretical explanation, experimentation, and personal reflection to attain deep learning.

I had the unique experience to spearhead the theory and practice of SUTD's novel educational program in the form of Designettes, and to participate closely in the 4D curriculum (Camburn et al., 2017; Sng et al., 2017; Camburn, Mignone, Arlitt, Venkataraman, & Wood, 2016; Telenko et al., 2016; Choo et al., 2014; Otto et al., 2014; Telenko, Camburn, Hölttä-Otto, Wood, & Otto, 2014). This work has also engendered other novel programs such as Design Odyssey, which connects students and young professionals to design innovation training. We pair organizations and bright students for a long-term engagement in which they deploy design innovation both from a deep design study effort during the school term and later as a full-time intern. I am also a firm believer in the importance of mentorship. I have mentored PhD students working towards their degree, masters and undergraduate students, as well as professional engineers and startup founders. I have guided more than a dozen undergraduate research assistant mentees over the last nine years. In my role as the senior Research Scientist of the SUTD-MIT International Design Centre (IDC), I assisted Prof. Lucienne Blessing and Prof. Kristin Wood to guide nearly 30 post-docs, PhD students, master's students, and design engineers during my term there. I helped them to flourish as individuals while concurrently producing novel research and delivering outstanding design outcomes for funded IDC projects. I have also mentored numerous capstone design teams at SUTD, teams from Design Odyssey, SUTD 10k, and nearly a dozen funded undergraduate led research (UROP) projects.

My students have won numerous awards. As an example, one of my mentees, Karen Sng, wrote a paper that was nominated for best paper at the 2015 IDETC-DTM conference. She was a sophomore undergraduate at the time. Her senior capstone project was also awarded best project university-wide. My student teams placed 6th and 10th out of 600 entries in Ikea's What Can Design Do Challenge 2016. Another of the capstone teams I mentored in 2015 went on to compete in the ASME-IDETC 2016 Student Capstone Competition and take first place worldwide for a microwave-based water extracting Mars rover. NASA has since approached the team and we will be building a second generation to test at NASA's Mars surface test arena at Johnson Space Center. Many of my student teams have received startup funding for projects they developed under my mentorship, an example is the micro electric vehicle developed by Brandon Chen, founder of FOM Innovations, which has received more than US\$50 thousand in startup funding. Another of SUTD graduate, Pei Shan, founded a local fruit recycling company under my supervision.

### LECTURING

At SUTD, in the fall of 2016, I was a cohort lecturer for Introduction to Design, 3.007. I have a passion for teaching design and bring my experience as a design practitioner into the classroom. My section received the highest average grades in the final design demo, which is anonymously graded by a random selection of the other course instructors. My student evaluations were above average for course instructors. Here is a quote from my teaching evaluations:

*"A very insightful instructor: gave good advice that the team could uptake despite us having a limited technical skill set. Also, provided us with good ways our thinking should go towards for the project."*

I have been giving lectures and working as a teaching assistant in Design Methodology since 2008 at the University of Texas at Austin where I was a Graduate Fellow during my PhD studies. I taught for ME 336J, which is the first component of the senior capstone course in design, for three years with Prof. Kristin Wood. I also taught for ME 338, which is a course in machine elements,

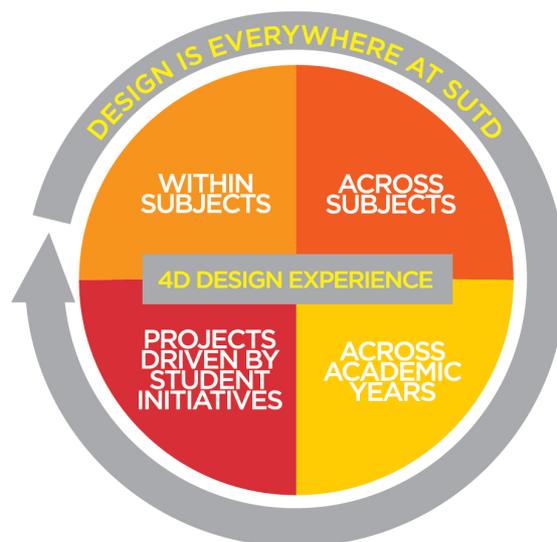


Figure 1: Singapore University of Technology and Design's Unique design centric curriculum integrates design in all courses – even liberal arts and humanities in order to build a strong problem solving skill set.

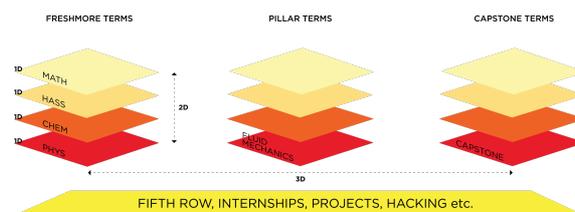


Figure 2: Graphical depiction of the 4D curriculum

and ME 355K, which is a course on engineering vibrations.

I developed, first-in-the-world, coursework materials on strategic prototyping. These course materials have been well received internationally and are used in design courses at several universities. They have become an essential component of capstone design courses at: Georgia Tech (Cassandra Telenko and Julie Linsey), The United States Air Force Academy (Daniel Jensen), University of Michigan (Panos Papalambros), Aalto University in Finland (Katja Otto) and SUTD (used in 3.007, core design course) and others.

## DESIGN INNOVATION:

|                            | <b>HEART (discover)</b>  | <b>EYES (define)</b>  | <b>MIND (develop)</b>  | <b>HANDS (deliver)</b>  |
|----------------------------|---|--|---|--|
| <b>DESIGN THINKING</b>     | Opportunity<br>User Studies<br>Context  | Problem Definition<br>User Modeling  | Ideation<br>Down Selection  | End User Testing<br>Product, Service, System Prototype   |
| <b>BUSINESS DESIGN</b>     | Market Assessment   | Value Proposition  | Critical Path<br>Organization Structure   | Cost-Benefit Analysis<br>Market Penetration  |
| <b>DESIGN ENGINEERING</b>  | Need Determination  | Task Clarification   | Embodiment Design   | Detail design<br>Testing<br>Production   |
| <b>SYSTEMS ENGINEERING</b> | Requirements Specification  | Functional Modeling (software, electrical, mechanical, systems)  | System Architecture   | Risk Analysis<br>Robustness<br>Risk Monitoring   |

Figure 3: The DI@SG program is an integrated design centre in which we provide solutions for industry partners alongside professional development. I spearheaded the creation of a unique integrated process model for design which supported the accreditation of the SUTD-MIT International Design Centre as Singapore's first accredited professional industrial design firm existing within an academic institution.

## WORKSHOPS & INNOVATION MATERIALS

I conducted numerous professional development workshops and seminars, training more than 500 professionals. These workshops provide training in design innovation and have been held in locations that include Papua New Guinea, the United States, China, and Singapore. In Singapore, I worked with many of the largest local organizations such as the Ministry of Defense (MINDEF), Defense Science and Technology Agency (DSTA), the Urban Redevelopment Authority (URA), and the Ministry of Education (MOE). I also worked with large corporations (i.e., NBC Universal) as well as local SMEs (e.g., Codomo and Gilmour Space Technologies). My workshops for strategic prototyping have been deployed at conferences such as at the Design Computation and Cognition Conference and the ASME International Design Engineering Conference.

The workshops I conducted take a project-based approach to learning design. I work with client organizations to identify key problems that they face. I then develop a set of coursework material that exposes professionals to the principles and practice of design innovation (DI) in a rapid and engaging manner. These workshops teach participants to use design methods and simultaneously lead to innovative design outcomes in their organization. I have run introductory workshops that take two hours and extensive courses spanning 15 weeks. In longer courses, participants apply DI to a real problem in their organization. As part of an extended engagement with DSTA, I also trained facilitators. These facilitators, in turn, participate in executing future workshops. Paired with a design team of 5-6 individuals, these facilitators guide these design teams in applying methods. Our work in design education at DSTA is one example of providing Singaporean organizations with a fundamental competitive edge. This work also supports the IDC. The DSTA collaboration alone has resulted in more than S\$250K in funding from courses and derivative projects emerging from the coursework.

I led development of the MicroDI experience in collaboration with Prof. Kristin Wood. The MicroDI experience is an essential component of the IDC design innovation offering. It is a 1.5-hour exercise that offers participants a bite-sized journey through the entire design innovation process in an engaging manner. The IDC MicroDI experience has been deployed to more than 1,000 participants and provides a foundational tool by which the IDC is advancing design innovation awareness in Singapore. I also led the development of a set of instructional cards that each describe an innovative methodology for design. These cards summarize advanced methods for design innovation. The DI Card Deck received the Singapore Good Design Mark Award.

## ETHOS

If design is a decision, as some believe, the role of the designer is to explore options. Particularly through multi-modal concept representations as supported by prototyping, simulation, and controlled experimentation. In this regard, my research interest and pedagogical style align perfectly with the ethos and distinguishing characteristics of OSU as a research and project oriented environment. I have lectured on prototyping in many of the design courses at SUTD, and my pioneer materials are being used around the world in multiple universities to guide prototyping in design courses. I believe that I can contribute novel course materials to the OSU curriculum; in particular, I currently have and could continue to develop coursework in mixed media prototyping, multi-physics simulation, prototyping of systems, aerospace propulsion, and additive manufacturing. I take great joy in joining students on a journey to develop new products and technology while at the same time imparting to them principles of design. Examples of existing courses that I could teach at OSU: ME 382, 383, 250, 373, 411, 413, 420, 422, 424, 451, and MFG 285, 336, 436, 437, 438. Examples of new courses that I could co-develop with OSU are: Design Prototyping, Design of Complex Systems, Hybrid Propulsion

I am fundamentally committed to the values of OSU as an academic institution deeply rooted in fundamental research. It is my belief that my experience and objectives align perfectly with entrepreneurial spirit of the Northwest and the vision of OSU and that I am therefore an ideal candidate for the position of Tenure-track Assistant Professor in ME with a focus in Design.

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